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# *Conceptualizing Awareness in Environmental Education: An Example of Knowing about Air-related Problems*

KAI PATA (kpata@tlu.ee), Center of Educational Technology,
Tallinn University, Tallinn, Estonia and
ENEKEN METSALU (e_metsalu@hotmail.com), Science Didactics Department,
University of Tartu, Tartu, Estonia

*ABSTRACT The notion of environmental awareness has been controversial in environmental literacy. Environmental awareness has been traditionally understood as conceptual awareness, but this study takes into consideration activity-related aspects of awareness, which should be integrated into an ontological model of developing environmental literacy. The empirical part of the study investigated the components of conceptual awareness using the model of air-related environmental issues. Eight classes of students (N=204) filled in an open-ended questionnaire one week after teaching about environmental issues was completed. The questionnaire investigated the extent of their awareness regarding the greenhouse effect, the depletion of ozone layer, acid rain and air pollution at general and local level. The teachers of the eight classes answered a different questionnaire relating to the teaching methods they used. The findings indicated that the students exhibited in their answers both conceptual and activity-related components of environmental awareness, and they faced difficulties in combining global and local aspects of environmental issues. Three types of students were identified on the basis of their awareness about the examined air-related issues: with mainly task- and process related and contextual awareness, with mainly social and contextual awareness, and with awareness where all aspects were combined. The active student-centred teaching method was related with the development of mainly the social and contextual awareness. Some students who participated in student-centred activities outdoors belonged to the awareness type in which task- and process-related contextual awareness was prevalent. The teacher-centred traditional methods developed both task- and process- related, and social and contextual awareness components.*

*KEYWORDS:* Acid rain, air pollution, environmental awareness, environmental literacy, greenhouse effect, ozone layer depletion.

## The Role of Awareness in Environmental Literacy

There are two discrete lines of argumentation relating to the environmental awareness. The first one considers environmental awareness as conceptual knowledge, while the second considers environmental awareness as closely connected to the actions and system components, where intentions and values also play an important role.

The aspects constituting environmental literacy, such as, "people's ability to deal with their immediate surroundings in an effective and stimulating manner" (Steele, 1980, p. 225), or environmental competence that indicates a "person's

capacity to perceive and interpret the relative health of environmental systems, and take appropriate action to maintain, restore, or improve the health of those systems" (Disinger & Roth, 1992, p. 3) vary extensively among different authors (Steele, 1980; Disinger & Roth, 1992; Roth, 1992; Pedersen, 1999; Hwang, Kim, & Jeng, 2000). For example, Steele (1980) *separates awareness and knowledge*; Disinger and Roth (1992) and Roth (1992) *refer only to knowledge,* while Roth (1992) differentiates between awareness, concern, understanding, and action as the levels of environmental literacy, and *relates awareness both with the affective and cognitive domains,* and Pedersen (1999) and Hwang, Kim, and Jeng (2000) *include awareness into the cognitive domain.*

Steele (1980) proposed that environmental competence has *perceptual, cognitive, affective, behavioural,* and *personal* components. The perceptual component involves the ability to ascertain, prioritize, and screen relevant aspects of the environment in terms of their adaptive and aesthetic properties. Cognitive component is related to the processes of storing, organizing, and recalling salient and meaningful aspects concerning the environment. The affective component refers both to positive and negative emotional responses towards the features of the environment. The behavioural element includes typical responses, copying strategies, and behaviours, while all these aspects are mediated by characteristics of the individual, such as, motivations, personality characteristics, expectations, cognitive styles, copying strategies, and past experience that constitute the personal components.

Steele (1980) suggested that there are three kinds of environmental competencies. The first kind consists of *personal style, attitude, and awareness.* This category includes personal awareness of one's environmental competencies, curiosity about the environment, and the ability to perceive the environment accurately. The second part is *environmental knowledge that* involves the acquisition of environmentally relevant facts and information, and the third aspect consists of *practical environmental skills.* Steele (1980) classified awareness in relation to the person's perceptions of the overall action-potentials of the environment for realizing certain intentions, but also related it to the person's self-awareness in this environment.

According to Disinger and Roth (1992), environmental literacy draws upon environmental sensitivity, knowledge, skills, attitudes and values, personal investment and responsibility, and active involvement. These can be divided into four strands, namely, *knowledge, skills, affect,* and *behaviour.* However, Roth (1992) distinguished between four stages of environmental literacy: *awareness* is the perception of human/nature interactions and consequences, in general or around a particular issue, which can be emotional, cognitive or both; *concern* is the perception of real or potential negative consequences of a set of human/nature interactions and feeling that some changes in those interactions need to occur; *understanding* is the acquisition of the detailed information of the present and future implications and consequences of current human/nature interactions, and alternative interactions, as well as, the acquisition of thinking and decision-making skills and their use in processing the information; and, finally, *action* is the application of any understandings to individual and corporate behavioural changes that modify human/nature interactions, in what is perceived as responsible ways for reducing or eliminating negative consequences. According to these categories, awareness is

rather the initial perception state of filtering out the important aspects of the problem issues from the environment in order to take action. This environmental awareness conception assumes that person's intentions are environmentally positive, either because of emotions or because of knowledge.

Pedersen (1999) has concretized the environmental competencies as follows: *conscientiousness* that involves primary enacting responsible environmental behaviours, and reflects favourable attitudes toward the environment, and some personal attributes of the individual; *environmental knowledge*; *practical skills*; and *resource conservation.* The intentions to carry out behaviours that are environmentally sustainable are the main focus. This suggests a tendency of relating environmental awareness primarily to certain nature-protective behaviours, and lack of awareness would suggest that people are not knowledgeable of environmental problems, or are not motivated to act according to environmental values. Thus, even if awareness is not mentioned, it is implicitly related with the knowledge domain.

Hwang et al. (2000) have classified the factors influencing *environmental behaviour* into three categories: *cognitive, affective,* and *situational* factors. Cognitive factors correspond to an individual's degree of awareness and knowledge of the environment, and major ecological concepts, including individual's own abilities and knowledge of action strategies. Affective factors involve emotions and feelings associated with environmental issues and ecological phenomena, and include attitudes and personality traits. Situational factors are linked to an individual's or group's situation, and include economic, demographic, and cultural constraints that may inhibit environmental behaviours. This classification contains both the environmental and ecological knowledge-related awareness components, and self-awareness of interacting potentials.

Findings of the participants' situation awareness in complex systems bring another line of argument, which relates awareness primarily to the perception of actions and the system as a whole (Endseley, 1988; Endsley & Robertson, 2000; Gutwin & Greenberg, 1996). The awareness research has long traditions in aviation (Endsley, 1988; Endsely & Robertson, 2000), and recently in workplaces (Gutwin & Greenberg, 1996) and learning environments (You & Pekkola, 2001). In these studies, the awareness was traditionally considered as an activity-centred perception. On the basis of the awareness studies by Endsley and Robertson (2000), it can be assumed that the *situation awareness* constitutes an important aspect of running the wide variety of complex systems, and that it is also relevant in case of taking actions during environmental problem situations.

These assumptions about situation awareness are made upon the man-made ontological systems rather than supported by neurobiological findings. Recent studies about primates' neural functioning and mirror neurons (Rizzolatti, Fadiga, Fogassi, & Gallese, 1996; Gallese, 2000) have brought the awareness aspects into the frontline of learning and taking action. Rizzolatti et al., (1996) and other subsequent studies have demonstrated that for primates there is a common functional mechanism based on the activation of mirror neurons, which *support body awareness* and *basic forms of social understanding.* Object observation, even within a behavioural context not specifically requiring an active interaction from the observer, deter-

mines the activation of the motor program that would be required for the observer to be actively interacting with the object (Gallese, 2000). There is evidence that humans would activate their mirror neurons, when just observing someone to perform a goal-directed action within the range of their interest, and that they would perceive the actions, sensation, and emotions of those they observe, as if they were doing similar actions or undergoing same emotions (Gallese, 2001; Gallese, Migone & Eagle, 2007). These studies suggested that awareness is triggered by a person's previous subconscious, or conscious goals and intentions, which makes him/her sensitive for certain activities in the surrounding environment, by perceiving and simulating them as his/her own actions and emotions at the brain level. Experiences from this embodied simulation (see Gallese, 2000) may be recorded and reactivated in new situations.

These findings suggest that a strong connection exists between awareness and the action domain, and that the priority of knowledge in the determination of environmental awareness has been over-prioritized, when outlining the environmental literacy components. The findings from studies indicating that awareness is perceived as an activity-related construct suggest that some of the components of environmental literacy and subsequent teaching practices might be revised.

## Awareness as a Conceptual Construct

The earlier explanations of developing students' environmentally sound behaviour relied heavily on the assumption that awareness is only a knowledge-related concept. Accordingly, Hungerford (1985) distinguished levels of a goal in teaching practice that could be related to the development and demonstration of environmentally responsible behaviour:

1. *Ecological concepts*: This attempted to provide learner with the ecological knowledge that would permit him/her to make ecologically sound decisions with respect to environmental issues.
2. *Conceptual awareness*: This attempted to develop a conceptual awareness of how individual and collective behaviours would influence the relationship between quality of life and the quality of the environment, and how human behaviour would focus on issues that must be resolved through investigation, evaluation, decision-making, and citizenship action.
3. *Issue investigation and evaluation*: This attempted to develop knowledge and skills needed to permit learners to investigate environmental issues and evaluate the alternative solutions for re-mediating these issues.
4. *Environmental action skills*: This attempted to develop those skills for learners that are necessary for taking positive environmental action in order to resolve or contribute to resolving environmental issues. It also improved the development of action plans by students and provided them with the opportunity to implement those plans, when they were willing to do so.

The awareness factor is missing from the models that predict ecological behaviour (Kaiser, Wölfing, & Fuhrer, 1999; Kaiser & Fuhrer, 2003). Kaiser et al. (1999) demonstrated that general ecological *behaviour* could be predicted by ecological

*behaviour intention*, which, in turn, is a function of *environmental knowledge* and *environmental values*. For the development of this model, the transportation issues were studied using a questionnaire expressing knowledge of the influence of global air-related issues, general ecocentric values, and behaviour intentions relating to the use of cars. Kaiser and Fuhrer (2003) suggested that environmental knowledge could be distinguished into *declarative knowledge* about how the environmental system works, *procedural (action-related) knowledge* addressing how to achieve particular conservation goals, *social knowledge* that relates human behaviour to the expectations, motives, norms, and actions of others, and *effectiveness knowledge* that consists of knowledge about the effectiveness of different conservation behaviours. They suggested that these four types of knowledge might influence people's attitudes towards environmental behaviours and their intentions to take action.

Tanner (1999) defined two kinds of awareness related to environmental behaviour, the personal awareness and the general problem awareness. *Personal awareness* reflects negative stressful feelings related to environmental problems, and an awareness indicating that environmental problems threaten personal health and well-being. *General problem awareness* focuses on the potential harmful outcomes for other people or the nature.

Based on a questionnaire of personal car use, Nordlund and Garvill (2003) developed another model of the factors that influence environmental behaviour. They demonstrated that *personal values* direct attention toward information in the environment that is congruent with the personal values, and result in an increased *general awareness* of the environmental problems that are considered as threats to biosphere and humankind as well. General awareness also influences the level of specific *problem awareness*, concerning negative environmental consequences of car traffic and perceived seriousness of these consequences. Specific awareness of the negative environmental consequences of car traffic and degree of seriousness of these consequences directly influence *personal norms*. The personal norms had the predicted positive effect on *behaviour* and willingness to reduce personal car use. Tanner (1999), on the contrary, found that neither personal nor general problem awareness was predictive of the behavioural reports, while several subjective and objective factors (eg., gender, car ownership etc.) were of significant importance.

These definitions of the awareness as an influential component affecting environmental behaviour represent *learned conceptual awareness* – specific environmental knowledge and attentiveness to some factors that are potentially harmful and not supporting their intentions.

### Awareness as an Activity-related Construct

The simplified understanding that teaching scientifically sound ecological conceptions would develop students' environmental awareness, and support relevant environmental behaviours has recently been rejected, demonstrating that knowledge itself would not guarantee learners' sustainable environmental behaviours (Hwang et al., 2000; Jensen, 2002, Nordlund & Garvill, 2003). Pruneau, Doyon, Langis, Vasseur, Ouellet, McLaughlin, Boudreau, and Martin (2006), and Jensen (2002) have found that cognitive factors influencing positively environmental

behaviour are *awareness of the problem, traditional environmental knowledge,* and *constructed knowledge centred on action.* These findings highlight the importance of broad situation- and action-centred awareness in determining behaviour.

Govern and Marsch, (2001) have assumed that in learning situations people rely on *situation awareness,* the gathering, incorporation, and utilization of environmental information to help them combine their unique knowledge and skills, and achieve their goals. At a very simple level, situation awareness is an appropriate awareness of a situation (Smith & Hancock, 1995). The core of the situation awareness is the progressive detection and projection of situation components in time. According to Endsley (1988), "situation awareness is the detection of the elements of the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in near future" (p. 97).

Stanton, Chambers, and Piggott (2001) suggested three theoretical perspectives relating to the situation awareness: the information-processing approach, the activity approach, and the ecological approach. In the information-processing model, the decision-making process is dynamic, and *obtaining situation awareness requires sequential development of three levels of awareness.* At the first level (*perception*), the actor would receive the raw information offered by the system, while, at the second level (*comprehension*), would comprehend the raw information for his/her purpose and would prioritize the information. At the third level (*projection*), the actor would project future situations and actions. The accuracy of the final projection is highly dependent upon the accuracy of the first and second levels of awareness (Endsley, 1995).

According to the activity approach to situation awareness suggested by Bedney and Meister (1999), the extent to which processes are involved in the person's conceptualization of the situation is dependent on the nature of the task and the goals of the individual. Their activity-related situation awareness model comprises the *meaning of the input information, goal, task conditions and situation awareness, conceptual model, past experience, decision-making activity,* and the *criteria for evaluation.* New information is perceived and interpreted through individuals' conceptual model of the world, goal-definition, and orientation in the task conditions and situation awareness, and consequently transformed into decision-making activities. Engagement in an activity is always regulated by motivation. Running the dynamic activity would suggest how to modify the evaluation criteria, which in turn would support building an experience and modifying the conceptual model of the world. Evaluation criteria are used to validate the necessity of activating certain components of the situation in the current task conditions. The development of situation awareness supports the decision-making activity and raises motivation.

According to the ecological approach to the situation awareness, developed by (Smith & Hancock, 1995), the awareness is neither resident in the world nor in the person, but it *emerges in the interaction of the person with the world.* The mental model of the world enables the subjects to anticipate events, directs the course of action and evaluates the outcomes. Unexpected outcomes would lead towards increased situation awareness.

Endsley (1995) has indicated that situation awareness is influenced by task, individual, and system factors. Personal factors, such as, ability, experience, and training contribute to different levels of comprehension of the same information, and reveal the objectives and expectations (Lee, Suh, & Whang, 2001). System factors, capacity, and type of information provided by the system also influence situation awareness. Stanton, Chambers and Piggott (2001) distinguished two interacting system elements: the persons and their reflection together (comprising working memory, mental models, knowledge, skills, and experience) and, the world. You and Pekkola (2001) categorised situation awareness into *user* and *workspace awareness.* User awareness represents direct actions occurring in the workspace, the information about *who* is present, whether they are available, and *what* they are doing. Workspace awareness means *understanding of the people's interactions* within shared workspace. This involves knowledge about the tasks and activities of those people. Gutwin and Greenberg (1996) have concretised that workspace awareness builds on:

- *Direct communication*: explicit communication through speech or gesture, often employing deictic reference.
- *Indirect productions:* utterances, expressions, or actions that are not explicitly directed at others, but that are intentionally public.
- *Consequential communication*: the visible or audible signs of interaction with a workspace. Watching someone work provides clues about their actions.
- *Feed through*: the observable effects of someone's actions on the workspace's artifacts. Seeing an object move indicates that someone is moving it.
- *Environmental feedback:* feedback from the environment or overall workspace caused by the indirect effects of someone's actions.

Integrating this dynamic action-related awareness into the theoretical models of environmental literacy development would enable to shift the focus from the currently declarative knowledge-centred education in environmental education towards promoting action-centred teaching methods. It is necessary to teach environmental problems as dynamic and complex phenomena (Pata, 2005), and the dynamic and activity-centred awareness conception would favour this approach.

## The Components of Awareness

The appropriate framework of concretizing the awareness components in environmental education could be derived from Sonnenwald, Maghlaughlin, and Whitton (2004), and the current study followed this framework. According to this framework, situation awareness is comprised of interrelated *contextual*, *task and process,* and *socio-emotional information.* This is in accordance with the types of environmental knowledge suggested by Kaiser and Fuhrer (2003). Contextual information is a broad sense of the context in which things are happening. Context can be defined as *'framework of meaning'* (Cool, 2001) or *'framework of understandings'* (Klein, 2000). Contextual awareness can be interpreted as an awareness of what the problem situation is, which aspects it comprises, and why the problem persists to exist (Nordlund & Garvill, 2003). Learners' task and process awareness consists of

noticing and considering this information (Sonnenwald et al., 2004). Task and process awareness is defined as being aware of the information about the current and relevant task activities and work processes (Carroll, Neale, Isenhour, Rosson, & McCrickard, 2003). Socio-emotional information is the interpersonal information about the collaborators, their skills, work styles, approach to concrete subject, likes and dislikes, personality, and emotional state (Sonnenwald et al., 2004). This framework could be simplified in terms of questions: *what is?* asks for semantic knowledge and is relevant for the contextual awareness; *why?/how?* questions are related with intentional framework and its application, what is common to the task- and process-related awareness, and *who?* questions clarify the socio-emotional awareness.

Most of the environmental literacy studies did not deal with the real environmental problem-solving situations, but ask about knowledge, values, awareness that the students claim to have, and the activities that they claim to undertake. Thus, if literacy components were studied with questionnaires, rather than measuring awareness components in action, it would only be possible of measuring students' knowledge of certain awareness aspects. Therefore, the differentiation has to be made of learned conceptual awareness, and situation awareness that would be the basis of real problem-solving in complex situations. In this study, it was intended to investigate the structure of students' learned conceptual awareness about air-related issues. The study attempted to investigate whether different types of environmental awareness occur, and how would the development of these awareness types be influenced by earlier teaching practices on air-related issues.

More specifically, the study attempted to investigate the following three questions:

1. Which specific awareness components compose Estonian students' knowledge about the greenhouse effect, the ozone layer depletion, acid rain and air pollution?
2. What are the general types of Estonian students' environmental awareness about air-related issues?
3. What is the relationship of Estonian students' environmental awareness types and the teaching approaches?

## Methodology

### Participants

The sample consisted of 204 students from 8 classes (4 classes of eighth-grade and four classes of ninth-grade students) from 7 Estonian elementary and secondary schools from rural and town areas. The students were administered a questionnaire consisting of open-ended questions after being taught about the air-related environmental issues (acid rain, ozon layer depletion, greenhouse effect, global warming). The science teachers were administered a different questionnaire relating to the methods of teaching they use and students' related activities.

**Instruments and Context**

According to the Estonian National Curriculum for Elementary and Secondary Schools (ENC, 2002), the air-related environmental issues are taught at medium (grade five) and upper basic (grades eight and nine) levels. In the syllabus, environmental issues are outlined in very general terms, emphasizing the need to teach these topics and relate the global to the local levels, for the important environmental problems, namely, global warming and the greenhouse effect, the ozone layer depletion, acid rain, and air pollution. Each teacher can select both the method and the depth of teaching in order to facilitate the knowledge construction process. There exists only one nationally approved textbook, where these issues are described in 7 pages. Textbook presents the topics mainly from the ecological viewpoint, explaining the nature of the phenomena, their causes, and strategies of how to control the situation, and the workbook presents only one graph-reading task about ozone layer depletion. The content of these teaching materials is not obligatory, and various other freely selected teaching resources can be used.

In order to investigate the environmental awareness components (see Sonnenwald et al., 2004), an open-ended questionnaire for the students was developed. Students' knowledge about four air-related topics, namely, the greenhouse effect, the ozone layer depletion, acid rain, and air pollution, was investigated using 7 identical questions for each topic:

*What is ... ?*

*Who/what causes ... ?*

*Which are the possibilities of avoiding it ...or dealing with its consequences?*

*Which are the consequences of... ?*

*Who/what causes ... locally?*

*Which are the possibilities of avoiding it ... or dealing with its consequences locally?*

*Which are the consequences of... locally?*

The open-ended questions enabled students to answer in general terms (supposedly global- and local-context answers were expected), while some questions specifically directed students to focus on the local aspects of environmental problems (supposedly local aspects were to be interrelated with global ones). The questionnaire was administered to the students one week after the teaching was completed.

Teachers were also administered a different open-ended questionnaire, where the teachers provided information about the teaching approach that they followed when teaching these air-related issues. The following questions were asked about greenhouse effect, ozone layer depletion, acid rain, and air pollution:

*What did you teach concerning these air-related issues?*

*Which examples did you use in teaching these issues?*

*Which activities did the students conduct at school/ at home relating to these issues?*

*What should be taught at basic school about these issues?*

*What would you like to teach about these issues in basic school?*

**Data Analysis**

Data from students' questionnaires were categorised according to their correctness into *wrong, partially correct,* and *correct* explanations. Students' replies were also classified into the types of *only global, only local,* or *interrelated local-global* explanations, as indicated in Table 1.

*Table 1*

*Examples of Categorizing Students' Answers Globally/Locally*

| Question | Only local | Only global | Interrelating global/local |
|---|---|---|---|
| *What is ...?* | Air pollution is the pollution of the clean air that we need to breathe in for living. This is caused by factories and cars. | Greenhouse gases ($CO_2$) get concentrated around Earth, but to get them out is more difficult and, therefore, the temperature has been increasing. | Air pollution is the general level of pollution in the air. It is caused by cars and factories. |
| *Who/what causes ..?* | Activities of people. | Using fossil fuels. | Natural conditions and weather, people in our country. |
| *Which are the possibilities of avoiding ... or dealing with its consequences?* | Old cars without anti-catalyst system must be banned. | Avoiding that the greenhouse gases were emitted to the atmosphere. | To use alternative energies, to add filters to the chimneys of large enterprises. |
| *Which are the consequences of...?* | The weather in Estonia becomes warmer, especially during winter. | Global warming, changes in the environment. | Global warming, changes in the seasons, the life-cycle of the bears changes, and they cannot sleep in winter. |

Two indipendent raters categorized the data assessing their correctness and the context of their answers to the open-ended questions. Cronbach alpha was used to find the inter-rater reliability of categorizing the correctness and the context of students' responses. The Chronbach alpha for correctness was 0.9 and for the global/local context 0.87.

In order to show the frequency of different types of answers to the questionnaire items, a cross-tabulation of students' awareness components was prepared with their correctness and context measures. To illustrate the students' awareness components of the air-related environmental issues, the Principal Component Factor analysis was carried out. The correctness and context variables of the seven awareness components questions (14 items) about each environmental issue were added to this analysis.

The factors from each Principal Component Factor analysis were subsequently

analysed with Hierarchical Cluster analysis using Ward method. The Hiararchical Cluster analysis with Principal Component analysis factors as variables was used to demonstrate, whether factors would form related awareness components. The Hiearchical Cluster analysis with students as cases was performed and it suggested that the meaningful number of awareness types among the participants could be 3. Consequently, the K-means analysis, seeking for 2–5 clusters, was performed and the solution with 3 clusters was selected according to the most significant differences between the cluster components. The classification basis of these clusters was demonstrated with the Canonical Discriminant analysis, using SPSS 14.0.

Teachers' questionnaires and lesson-plans were also analysed using qualitative content-analysis methods. Two categories were formed: *traditional teaching* and *active teaching* method. Cross tabulation and Chi square analysis was performed to demonstrate the interrelations of the teaching method and students‘ awareness types.

## Results

### Students' Awareness of Air-related Environmental Issues

In Table 2, the results of students' awareness about different environmental issues are presented. For each question, the correctness and the context of students' replies were also taken into account. It was presupposed that the structure of students' awareness about each of the selected air-related issues might be illustrated with the factorial components. Principal Component Analysis was conducted with the correctness and the context categories of seven questions (14 items) related to each problem issue. Tables 3, 4, 5, and 6 present the factor components for each of the air-related environmental problem.

### Greenhouse Effect

It could be generalised from Table 2 that students had difficulties in explaining correctly the greenhouse effect. They were also more aware of the local actors that contribute to the Greenhouse effect, and the students exhibited both global also local consequences of the problem, and local and global strategies of dealing with it as well. Students could not however explain the greenhouse effect in an interrelated way by considering both global and local contexts.

Students' explanations of the greenhouse effect could be characterised with 4 components, explaining 66.22 % of variance, as indicated in Table 3. The first component could explain 37.34 % of the total variance and was related to students' answers about *what the greenhouse effect is,* and their *general and local strategies of dealing with global warming.* The second component could explain 11.05 % of the total variance, and was related to the *local actors* and the *local strategies concerning the increase of greenhouse effect.* The third component could explain 9.72 % of the total variance, and was related to the *general and local consequences of global warming.* Lastly, the fourth component could explain 8.10 % of the variance and was related to students' awareness about *who/what causes the increase of greenhouse effect.*

### Ozone Layer Depletion

Data from Table 2 demonstrate that students did not have difficulties in explaining partially correct or correctly what the ozone layer depletion is, and their

*Table 2*

*Components of Students' Awareness about Greenhouse Effect, Ozone Layer Depletion, Acid Rain, and Air Pollution According to their Correctness and their Context (%)*

| Correctness/context | | Greenhouse effect | | | | Ozone layer depletion | | | | Acid rains | | | | Air pollution | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | M | G | L | GL | M | G | L | GL | M | G | L | GL | M | G | L | GL |
| What is…? | M | 12.7 | 4.9 | | | 6.8 | | | | 12.2 | 0.4 | | | 7.8 | 0.4 | | |
| | W | 0.4 | 25 | 2.4 | 0.9 | | 11.2 | 0.4 | | | 25.9 | | | | 14.7 | 0.9 | |
| | PC | 1.4 | 39.7 | 2.4 | 0.4 | 0.4 | 47.5 | 0.4 | | | 41.6 | 0.4 | | | 59.8 | 3.4 | |
| | C | | 8.8 | 0.4 | | | 32.8 | | | | 18.6 | 0.4 | | | 11.7 | 0.9 | |
| Who/what causes …? | M | 5.8 | | | | 5.8 | | | | 11.2 | 0.4 | | 0.4 | 3.4 | | | |
| | W | | | 0.4 | | | 0.4 | 0.9 | | | 3.4 | 0.9 | | | | 0.9 | |
| | PC | 0.4 | 2.9 | 2.4 | 2.9 | | 1.9 | 4.4 | 1.4 | 0.4 | | 0.9 | 0.9 | | | | 0.4 |
| | C | 0.4 | 14.2 | 59.3 | 10.7 | | 12.7 | 60.7 | 11.2 | | 13.2 | 59.8 | 7.8 | | 12.2 | 59.3 | 23.5 |
| Which are strategies? | M | 15.1 | | | | 8.3 | 0.4 | | | 22.5 | 0.9 | 0.4 | | 9.8 | 1.4 | | |
| | W | | 6.3 | 0.9 | | | 10.7 | 2.4 | | | 13.7 | 4.4 | 0.4 | | 7.3 | 2.4 | 0.9 |
| | PC | | 17.1 | 12.2 | 4.4 | | 10.7 | 2.4 | 4.9 | | 5.3 | 3.4 | 1.9 | | 7.3 | 0.9 | 0.4 |
| | C | | 24.5 | 15.1 | 3.9 | | 53.9 | 3.4 | 2.4 | | 32.3 | 5.8 | 8.3 | 0.9 | 49.0 | 6.8 | 12.2 |
| Which are the consequences of…? | M | 4.4 | | | | 9.3 | 0.9 | | | 7.3 | 0.4 | | | 7.8 | | | |
| | W | 0.4 | 9.8 | 1.4 | | | 8.3 | 0.4 | | | 11.2 | | | | 11.2 | 1.4 | |
| | PC | | 8.8 | 0.9 | | | 17.1 | | | | 14.2 | 0.4 | | | 10.2 | | |
| | C | | 73.5 | | 0.4 | | 57.3 | 4.4 | 1.9 | | 51.9 | 14.2 | | | 68.1 | 0.4 | 0.4 |
| Who/what causes …locally? | M | 14.2 | | | | 4.9 | | | | 19.1 | | 0.4 | | 7.3 | | | |
| | W | | 0.4 | 5.3 | | | | 2.4 | | | 0.4 | 0.4 | | | | 1.9 | |
| | PC | 0.4 | 1.4 | 76.9 | 0.9 | | | 0.9 | | | | | | | | 0.9 | |
| | C | 14.2 | | | | 0.4 | 3.9 | 86.2 | 0.9 | 0.4 | 1.4 | 77.4 | | 0.4 | 0.4 | 88.7 | |
| Which are strategies locally? | M | 24.0 | | | | 19.1 | | 0.4 | | 23.5 | | 1.9 | | 18.6 | | 0.4 | |
| | W | | 1.4 | 10.2 | | | | 12.2 | | | 0.9 | 16.1 | | | 0.4 | 17.1 | |
| | PC | | 0.9 | 23.0 | | | | 13.2 | | | | 8.8 | | | 0.4 | 5.3 | |
| | C | | | 39.7 | 0.4 | | 2.4 | 51.4 | 0.9 | | 1.4 | 47.0 | | | 1.4 | 55.8 | |
| Which are the consequences of…locally? | M | 29.9 | | 1.9 | | 32.8 | | 0.4 | | 21.0 | | 0.4 | | 25.9 | | 1.4 | |
| | W | | 2.4 | 8.3 | | | 0.9 | 28.4 | 0.4 | 0.4 | 4.4 | 15.1 | | 0.4 | 1.4 | 21.5 | |
| | PC | | | 3.9 | | | 0.4 | 3.4 | | | 0.4 | 5.3 | 0.4 | | 0.9 | 12.2 | |
| | C | 0.4 | 0.9 | 51.9 | | 0.4 | 2.4 | 29.9 | | 0.4 | 1.4 | 50 | | | 4.9 | 30.8 | |

Note: M - missing; W – wrong; PC – partially correct; C – correct; G – global; L – local; GL – global/local

*Table 3*

*Component Matrix of Principal Component Analysis concerning the Greenhouse Effect Questions*

| Question types about greenhouse effect | What it is and strategies (37.34 % ) | Who/what causes it locally and local strategies (11.05 %) | Consequences of the problem (9.72 %) | Who/what causes it in general (8.10 %) |
|---|---|---|---|---|
| What is... * | 0.705 | | | |
| What is... + | 0.681 | | | |
| Strategies locally * | 0.667 | 0.487 | | |
| Strategies locally + | 0.645 | 0.556 | | |
| Strategies in general * | 0.563 | | 0.406 | |
| Strategies in general + | 0.414 | | | |
| Who/what local+ | | 0.916 | | |
| Who/what local* | | 0.896 | | |
| Consequences local * | | | 0.915 | |
| Consequences local + | | | 0.895 | |
| Consequences in general * | | | 0.535 | |
| Who/what in general * | | | | 0.859 |
| Who/what in general + | | | | 0.794 |
| Consequences in general + | | | | 0.482 |

Note: * correctness; + context

descriptions were related to a global context. Students were mainly aware of the local actors that contribute to the ozone layer depletion, but there was also partial understanding of the actors at the global and the local levels. Students' task- and process-related awareness about strategies of dealing with ozone layer depletion was related with global contexts in terms of the general question, while the local question triggered explanations restricted to the local context. Students' knowledge of the general consequences of ozone layer depletion was presented in global context. When replying to questions relating to the local context, students referred only to local consequences, but their knowledge was often wrong.

Students' explanations of the ozone layer depletion could be characterised with 5 components, explaining 71.47 % of total variance, as indicated in Table 4. The first component could explain 34.98 % of the total variance and was related to the *actors who/what cause ozone layer depletion.* The second component could explain 13.20 % of the total variance and was related to the *general consequences of ozone layer depletion.* The third could explain 8.35 % of the total variance and was related to *strategies explaining how to deal with the ozone layer depletion.* The fourth factor could explain 7.64 % of the total variance and was related to the *local consequences of the ozone layer depletion,* and, finally, the fifth component could explain 7.30 % of the total variance and was related to students' explanations of *what the ozone layer depletion is.*

**Acid Rain**

As indicated in Table 2, students' explanations, about what the acid rain is, indicated their limited knowledge about the phenomenon. Students connected the actors causing acid rain with local context, and only few students could relate

*Table 4*

*Component Matrix of Principal Component Analysis concerning the Ozone Layer Depletion Questions*

| Question types about ozone layer depletion | Who/what causes it? (34.98%) | General consequences of the problem (13.20%) | Strategies of solving the problem (8.35%) | Local consequences of the problem (7.64%) | What it is? (7.30%) |
|---|---|---|---|---|---|
| Who/what local + | 0.816 | | | | |
| Who/what local * | 0.800 | | | | |
| Who/what in general + | 0.711 | | | | |
| Who/what in general * | 0.672 | | | | |
| Consequences in general + | | 0.800 | | | |
| Strategies in general + | | 0.683 | | | |
| Consequences in general * | | 0.668 | | | |
| Strategies locally * | | | 0.872 | | |
| Strategies locally + | | | 0.773 | | |
| Strategies in general * | | 0.501 | 0.574 | | |
| Consequences local + | | | | 0.848 | |
| Consequences local * | | | | 0.803 | |
| What is…* | | | | | 0.843 |
| What is…+ | | | | | 0.814 |

Note: * correctness; + context

both local and global actors to acid rain. Students' knowledge describing the strategies for dealing with acid rain and its consequences was related to only global, but also to global/local aspects as well, while for the local context only local strategies and consequences were mainly mentioned. More importantly, students provided mainly wrong answers, when referring to the strategies of how to deal with acid rain and its consequences.

Students' explanations of acid rain could be characterised with 4 components, explaining 73.55 % of the total variance, as indicated in Table 5. The first component could explain 47.69% of the total variance, and was related to *the local actors contributing to acid rain and the strategies for effectively dealing with the phenomenon. The* second component could explain 10.56% of the total variance, and was related to students' attempts to explain *what acid rain is and which are their consequences in general.* The third component could explain 8.14% of the total variance, and was related to students' knowledge about *local strategies of dealing with acid rain and its consequences.* The last component accounted for 7.15 % of the total variance and was related to the *actors who contribute to acid rain.*

**Air Pollution**

In general, students' knowledge about air-pollution was limited, as indicated in Table 2. Students could name both local and inter-related global-local actors as responsible of air pollution issues, but, in the local context, only local actors were identified. Students' task- and process-related awareness of strategies referring to the ways of how to deal with air pollution was dependent of the type (general or

*Table 5*

*Component Matrix of Principal Component Analysis with Acid Rain Questions*

| Question types about acid rains | Who/what causes it and which are general strategies (47.69%) | What it is and which are general consequences (10.56%) | Local strategies and consequences (8.14%) | Who/what causes it (7.15%) |
|---|---|---|---|---|
| Who/what local + | 0.774 | | | 0.514 |
| Who/what local * | 0.769 | | | 0.521 |
| Strategies in general * | 0.697 | 0.405 | | |
| Strategies locally * | 0.637 | | 0.477 | |
| Strategies locally + | 0.621 | | 0.525 | |
| Strategies in general + | 0.591 | | | |
| Consequences in general + | | 0.760 | | |
| What is…+ | | 0.727 | | |
| Consequences in general * | | 0.672 | | |
| What is…* | | 0.672 | | |
| Consequences local + | | | 0.855 | |
| Consequences local * | | | 0.834 | |
| Who/what in general + | | | | 0.866 |
| Who/what in general * | | | | 0.781 |

Note: * correctness; + context

local) of the question, but they distinguished between strategies concerning the local and the global context, while some students provided explanations interrelating them. A high amount of wrong answers referring to local consequences was noticeable, and students' knowledge about the consequences of air pollution was often incorrect, when referring both to the local and the global context.

Students' explanations of air pollution could be described with 3 components, explaining 59.21 % of the total variance, as indicated in Table 6. The first component could explain 36.49 % of the total variance, and was related to the *strategies for reducing the air pollution issues and its consequences. The* second component could explain 13.61 % of the total variance and was related to the *actors who cause air pollution,* and the third component could explain 9.10 % of the total variance, and was related to the knowledge *referring to air pollution and its consequences in general.*

**Types of Awareness about Air-related Issues**

The factor components from each air-related problem issue were analysed with Hierarchical Cluster analysis using the Ward method. The first analysis was conducted using the factor components as variables. Figure 1 shows the results of this analysis and the three clusters that were identified. Cluster I included mainly the awareness components of the actors/sources that contribute to the air-related issues, and Cluster II included mainly the awareness components relating to scientific explanation of each problem and the consequences accompanying it. Cluster III included mainly the awareness components relating to the consequences of the

*Table 6*

*Component Matrix of Principal Component Analysis concerning the Air Pollution Questions*

| Question types about air pollution | Strategies and consequences (36.49 %) | Who/what causes it? (13.61 %) | What it is and which are its consequences in general? (9.10 %) |
|---|---|---|---|
| Consequences local * | 0.823 | | |
| Strategies locally * | 0.793 | | |
| Consequences local + | 0.784 | | |
| Strategies locally + | 0.725 | | |
| Strategies in general * | 0.551 | | |
| Strategies in general + | 0.420 | | |
| Who/what local + | | 0.865 | |
| Who/what local * | | 0.863 | |
| Who/what in general * | | 0.719 | |
| Who/what in general + | | 0.617 | |
| What is...+ | | | 0.803 |
| What is...* | | | 0.702 |
| Consequences in general + | | | 0.671 |
| Consequences in general * | 0.495 | | 0.573 |

Note: * correctness; + context

problems and the strategies for facing them. Only the factor components of the strategies of dealing with the greenhouse effect and global warming were included in both Clusters I and II.

*Cluster I: Awareness of actors/sources causing the problem*

Air-pollution: Who/what causes it?
Ozone layer depletion: Who/what causes it?
Greenhouse effect: Who/what causes it in general
Greenhouse effect: Who/what causes it locally and which are local strategies?
Acid rain: Who/what causes it?

*Cluster II: Awareness of the scientific explanation of the problem and of its consequences*

Air pollution: What is the problem, and which are its consequences in general?
Acid rain: What is the problem, and which are its consequences in general?
Greenhouse effect: What is the problem, and which are the strategies for solving it?
Ozone layer depletion: What is the problem?
Ozone layer depletion: General consequences of the problem

*Cluster III: Awareness of the problem consequences and strategies to solve it*

Ozone layer depletion: Local strategies
Acid rains: Local strategies and local consequences
Air pollution: Strategies and consequences
Ozone layer depletion: Local consequences of the problem
Greenhouse effect: Consequences of the problem
Acid rains: Who/what causes it, and strategies for solving it

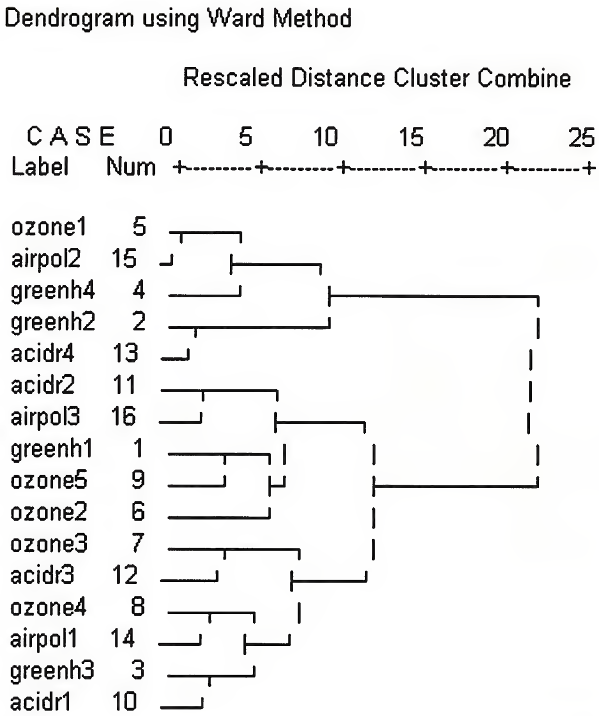


*Figure 1. Hierarchical Cluster Diagram of the Awareness Components about the Air-related Issues (Labels are the Factor Components from Tables 3, 4, 5 and 6)*

The Hierarchical Cluster analysis using the Ward method was then conducted with the students as cases. The cluster structure suggested that students could be described with 3–5 types of general awareness. Next, the K-means analysis was performed, searching for 3–5 clusters. The cluster structure distinguished three types of students. The clusters differed significantly ($p<0.01$) on the basis of most of the factor components, as indicated in Table 7.

The characteristic components distinguishing each awareness type were found with the Canonical Discriminant analysis. Two discriminant functions were found:

*Function 1*: C=0.64 (who/what causes air pollution) + 0.36 (who/what causes greenhouse effect) + 0.465 (who/what causes the ozone layer depletion) + 0.59 (local consequences of the ozone layer depletion) + 0.50 (strategies for solving acid rain)

*Function 2:* C=0.466 (strategies for solving air pollution) – 0.36 (who/what causes air pollution) + 0.31 (what is the greenhouse effect and strategies for solving it) – 0.51 (who/what causes the ozone layer depletion) + 0.37 (who/what causes acid rain and strategies for avoid them).

The first discriminant function described 67.2 % of the variance (eigenvalue 4.05) and the second 32.8 % of the variance (eigenvalue 1.97). According to Wilks

*Table 7*

*ANOVA with K-means Analysis Distinguishing the Types of Students' Awareness Clusters ($N_1$=59, $N_2$=13, $N_3$=132) According to the Factor Components*

| Factor components | Cluster | | Error | | F | Sig. |
|---|---|---|---|---|---|---|
| | Mean Square | df | Mean Square | df | Mean Square | df |
| Greenhouse effect 1: What it is, and which are strategies to solve it? | 19.936 | 2 | 0.812 | 201 | 24.56 | 0.001 |
| Greenhouse effect 2: Who/what causes it locally and which are local strategies? | 11.310 | 2 | 0.897 | 201 | 12.60 | 0.001 |
| Greenhouse effect 3: Consequences of the problem | 16.681 | 2 | 0.844 | 201 | 19.76 | 0.001 |
| Greenhouse effect 4: Who/what causes it in general | 15.826 | 2 | 0.852 | 201 | 18.56 | 0.001 |
| Ozone layer depletion 1: Who/what causes it? | 50.949 | 2 | 0.503 | 201 | 101.29 | 0.001 |
| Ozone layer depletion 2: General consequences of the problem | 5.434 | 2 | 0.956 | 201 | 5.68 | 0.004 |
| Ozone layer depletion 3: Local strategies | 16.327 | 2 | 0.847 | 201 | 19.26 | 0.001 |
| Ozone layer depletion 4: Local consequences of the problem | 24.619 | 2 | 0.765 | 201 | 32.18 | 0.001 |
| Ozone layer depletion 5: What it is? | 5.543 | 2 | 0.955 | 201 | 5.80 | 0.004 |
| Acid rains 1: Who/what causes it, and strategies to solve it | 21.523 | 2 | 0.796 | 201 | 27.04 | 0.001 |
| Acid rains 2: What it is, and which are its consequences in general? | 10.092 | 2 | 0.910 | 201 | 11.09 | 0.001 |
| Acid rains 3: Local strategies and local consequences | 29.359 | 2 | 0.718 | 201 | 40.90 | 0.001 |
| Acid rains 4: Who/what causes it? | 7.202 | 2 | 0.938 | 201 | 7.67 | 0.001 |
| Air pollution 1: Strategies and consequences | 37.788 | 2 | 0.634 | 201 | 59.60 | 0.001 |
| Air-pollution 2: Who/what causes it? | 45.928 | 2 | 0.553 | 201 | 83.05 | 0.001 |
| Air pollution 3: What it is, and which are its consequences in general? | 2.932 | 2 | 0.981 | 201 | 2.99 | 0.053 |

Lambda test, the two functions accounted for 100 % of the variance ($\lambda_1$=0.067, $\chi_1^2$= 524.36, $df_1$=32, $p_1$<0.001; $\lambda_2$=0.033, $\chi_2^2$= 210.93, $df_2$=15, $p_2$<0.001). The first function had the strongest absolute correlations with *who/what causes the greenhouse effect* ($r$=0.37) *and the ozone layer depletion* ($r$=0.35) components. The second function correlated with *strategies of how to avoid the ozone layer depletion, and which are its consequences* ($r$=0.46), and with *who/what causes the greenhouse effect* ($r$=-0.47) and the *ozone layer depletion* ($r$=-0.39) components. The first function was clearly related to the 'Awareness of actors/sources causing the problem,' while the second function distinguished between two types of students on the axis of 'Awareness of the problem consequences and strategies for solving it' and 'Awareness of actors/sources causing the problem.' Figure 2 presents the types of students' awareness according to these functions.

**Teaching Approaches and Students' Awareness about Air-related Issues**

The environmental education issues are usually taught in autumn or spring of the Estonian school term. Traditionally only one lesson is devoted to the air-related

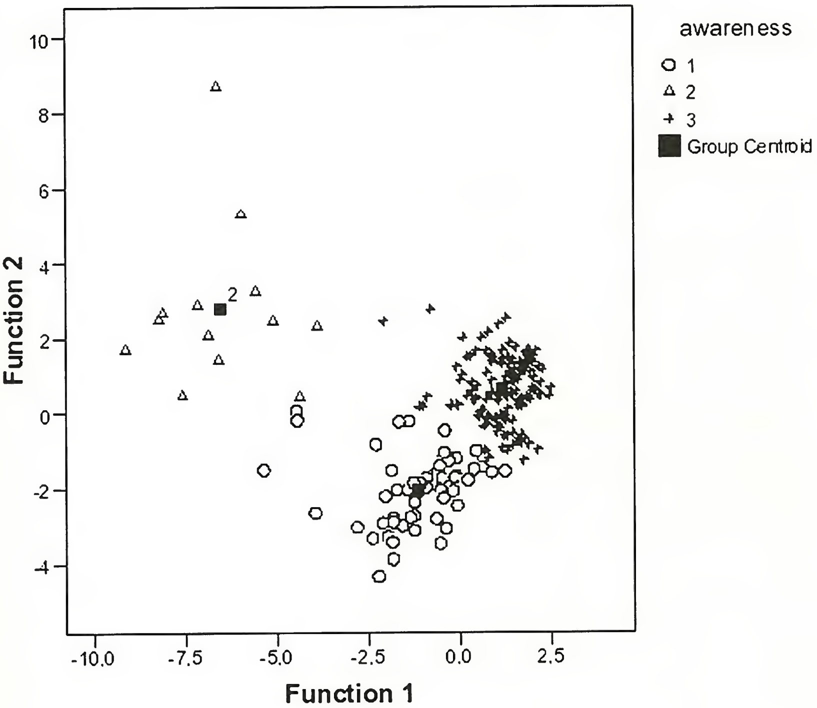


*Figure 2. The Types of Students' Awareness according to the Canonical Discriminant Analysis:*

*1 – Awareness Who/What causes the Air Pollution, the Greenhouse Effect and the Ozone Layer Depletion Problems;*

*2 – Awareness of the Strategies for solving the Greenhouse Effect, Acid Rains and the Ozone Layer Depletion Problems, and which are their Consequences;*

*3 – Awareness of the Strategies for solving the Greenhouse Effect, Acid Rain and the Ozone Layer Depletion Problems, and which are their Consequences + Awareness Who/What causes these problems.*

environmental issues in grade eight or grade nine. Two types of teaching-methods about the air-related issues were identified based on teachers' answers. *Traditional teacher-centred* and *student-centred teaching*. Example 1 describes what the teachers did in their lessons about the greenhouse effect, acid rain, the ozone layer depletion and air pollution.

Example 1. Types of teaching methods about the air-related issues

*I. Traditional teacher-centred teaching:* Teacher conveys new information, he/she dictates new information, writes it on the blackboard in a structured way, and students copy it. Textbooks and workbooks are used for studying the content, and, at the end of the lesson, some related questions are raised on the basis of the new material.

> *Teacher X used the following scheme: Acid rain: i) causes, ii) consequences, iii) how to avoid them. They discussed the topic and students provided examples.*

*The home-task asked the students to answer the questions in their workbook.*

*Teacher Y used the questions in the textbook and the workbook, students watched a film about air pollution in the classroom, and, at the end of the lesson, the topics were also summarised.*

*II. Active student-centred teaching:* The students are actively involved in the knowledge-construction process. Students are supported to express their knowledge about air-related issues before teaching. New knowledge is negotiated during discussions in the classroom setting.

*Teacher Z initiated a discussion concerning the causes environmental problems, and why these are harmful. Students went outdoors and counted the cars at a nearby street, and were instructed to prepare posters about the air-related issues. The students were also asked to fill in worksheets, which the teacher developed, and the students watched a film about air-problems in the city.*

*Teacher W initiated brainstorming in the classroom, environmental posters were designed and the home-task was to prepare a presentation about the air-related issues using PowerPoint. Teacher discussed with students the questions from the previous state exams, concerning the air-related issues.*

Chi square analysis indicated that the students from the student-centred approach belonged significantly ($\chi^2$=10.102, *df*=2, *p*.<0.001) more often than expected to the second awareness type where students were *not aware of who/what causes these air-related environmental problems,* but they *were aware of the strategies for solving them.* Students who participated in the active teaching approach belonged significantly less than expected to the third awareness type where the students were *aware of who/what causes the problems, which are the strategies for solving them, and which are their consequences.* It was also found that several students from teacher Z belonged to the second cluster where students had *mainly task- and process-related awareness.* These students had the lesson outdoors.

## Discussion

The present study investigated the components of Estonian students' constructed conceptual awareness about the air-related issues, by separating their knowledge about certain environmental problems into several components relating to: i) the general knowledge about each problem, ii) the task- and process-related aspects of how to approach the solution of the problem (using either the avoidance tactics or dealing with the consequences of the problem), and iii) the social and contextual components concerning the causes of the problem, and its consequences. This distinction was theoretically derived from the awareness classifications of Sonnenwald et al., (2004), Carroll et al., (2003), and Nordlund and Garvill (2003), and the environmental knowledge classification of Kaiser and Fuhrer (2003). However, this classification was only the starting-point of investigating how Estonian students would use these components in explaining the greenhouse effect, the ozone layer depletion, acid rain, and air pollution.

The results indicated that depending on the problem, students integrated several conceptual awareness components, when explaining *What* the problem was

about, *Who* was responsible for the its emergence, how to deal with its consequences, and *How* it should be solved. Students appeared to face difficulties to attribute these air-related environmental issues to several factors, and to describe their consequences. The factor analysis component structure indicated that knowledge about these problems was related to contextual, and task- and process-related aspects of the problem. Students provided explanations about each problem by referring to their consequences or the appropriate strategies for solving the problem. For example, students were fully aware about the task- and process-related aspects for reducing the ozone layer depletion and air pollution, and could explain the consequences of the greenhouse effect and the ozone layer depletion. Students also tended to integrate the strategies for solving the problems and the causes of them, and present both as a kind of joint components. Although the questions about each air-related environmental issue asked for a clear distinction between the problem and its causes, and between the strategies for solving the problem and its consequences, students' replies did integrate different awareness components and joint factors were identified. It seems that the teaching approaches did not address separately these aspects in a clear way, and that the students were unable to represent their general awareness of the problem into separable components.

The questions relating to social and contextual, and task- and process-related awareness addressed both the general and the local level. It was expected that the students would be able to activate their knowledge relating to both the global and the local aspects, but the majority of them could only make reference to the local actors responsible for causing these air-related issues. Students' task- and process-related awareness for the greenhouse effect related both the global and the local strategies, but, for other air-related issues, students made reference mainly to the global strategies, and explained the consequences of the problems mainly at the global level.

When the same awareness questions referred to the local context, only the local actors were mainly identified. Students' answers concerning the local actors about greenhouse effect were partially correct, while students exhibited correct understanding concerning the actors (who/what causes), and the other factors contributing to the other issues. Students' task- and process-related awareness of the strategies for locally solving the air-related problems, and their understanding about the local consequences of these issues were restricted to explanations relating only to the local context. The analysis of students' answers also indicated that they had wrong or incomplete understandings about the local consequences of the ozone layer depletion, acid rain, and air pollution, while they exhibited a better understanding for their global consequences. However, students' knowledge concerning different strategies for solving these problems at the global and the local levels was wrong or partially correct in most of the cases, and they seldom integrated global and local contexts.

These results clearly point out the major problems relating to the teaching of these environmental issues and demonstrate the need to adopt teaching that will attempt to integrate both global and local aspects when explaining them. These teaching approaches seem to be promising in providing a better understanding of the influence of global actors, and the need for local action and local strategies,

and their impact on the magnitude of the problems. Teaching approaches that distinguish the global and local awareness components for environmental issues could also present a more holistic picture and better understanding of the air-related environmental problems.

It was identified that students belonged to three awareness clusters. Unexpectedly, students' scientific knowledge (*What is* ...) about the problems was not one of the distinguishing components among the awareness clusters. This was a rather surprising result, because the scientific explanations relating to the causes of the greenhouse effect, the ozone layer depletion, acid rain, and air-pollution were the main focus of teaching. However, data indicated that the scientific explanations relating to these problems were not correctly conceptualized. The distribution of students between awareness types indicated main differences between those who had only social and contextual awareness, and those who had the task- and process- related awareness, while a smaller group of students appeared totally different from the whole sample, because of their low level of social and contextual awareness, although they had task and process awareness.

The results did not provide strong support for any of the different teaching approaches that the teachers applied in their classrooms and outdoors. The students from student-centred approaches were mainly aware of the actors causing the problem, indicating that the use of methods, such as, making posters of environmental issues or watching films about air-related issues in the cities, were rather more effective in addressing the social awareness (eg., Teacher W). Several students who received active teaching outdoors (eg., Teacher Z) had mainly task- and process-related awareness. The application of active teaching methods was not however more effective in general, because teachers, following traditional approaches, tended to clearly elaborate most of the conceptual awareness components in their lectures (eg., Teacher X), and their students provided all awareness components of these problems.

The overall results of the study seem to indicate that the conceptual awareness of task- and process-related aspects did not develop, when teachers used mainly the student-centred approaches of brainstorming and constructing posters relating to the air-related environmental issues. Notably, outdoor activities, such as counting the cars in the street, were more effective towards developing mainly task- and process-related awareness about the specific air-related problems. However, the general contextual awareness, and social awareness components of environmental issues remained unclear to the students. These preliminary findings need to be further investigated in real or simulated complex situations, before reaching any final conclusions relating to appropriate teaching strategies fostering environmental awareness development.

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